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Volume 41 October, 1955 *Number 10*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Modern Oils
for
Modern Engines

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Vol. XLI October, 1955 No. 10

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Modern Oils for Modern Engines

PISTON engines have undergone steady development with corresponding improvements in performance. These improvements are readily apparent to the car owner. To many car owners, the crankcase oils perform their function in secret places and the fact that the development of motor oils has kept pace with that of the engine is not universally appreciated. The purpose of the following article is to show how the modern oil meets the rather unique requirements of the modern engine.

MODERN ENGINES

In the early days of the automobile, little attention was given to the lubrication of an automotive engine. Although there were many opinions as to the best way to lubricate the engines, little or no thought was given to the quality of the engine oil that was used, and periodic oil changes were not considered necessary. Crankcase deposits with these early engines did not seem to be a problem, primarily because of the high oil consumption rates and the cool running engines that were a result of their large size in comparison with their power output. Automotive engine design has never remained static, and as improvements were made in engine design, more severe operating conditions were imposed on the oil. Consequently, the importance of oil quality became more and more apparent. Improvements in both engine design and metallurgy over the years have resulted in more efficient and more trouble-free engines. Changes in engine design up until World War II were made at a steady but gradual rate. The period since World War II, however, has seen some remarkably rapid changes in automotive engines. Figures 1 through 4 show some of the changes in engine design from 1946 through 1955 that have imposed heavier demands on the motor oils which must lubricate these engines. These figures show the trend in the averages, and in some cases the maximums, of the characteristics of the automotive engines manufactured in this country. Figure 1 shows the trend in compression ratio over the past eleven years. Compression ratio is the ratio of the volume of air-fuel mixture in the cylinder when the piston is at the bottom of the stroke to the volume when the piston is at the top of the stroke. At first glance, it would seem that increasing the compression ratio would have little or no effect on the crankcase oil. However, when the compression ratio is increased, the pressures and temperatures in the combustion chamber are also increased. Greater pressure in the combustion chamber results in higher loads on the piston pins, connecting rod bearings, crankshaft main bearings and piston rings. The crankcase oil must be able to adequately lubricate these parts under the increased loads. In the case of the piston rings, the oil must keep wear to a minimum for most efficient engine operation. If piston rings or cylinders are not adequately protected against wear, the proper clearances will not

be maintained and there will be excessive blow-by of gases from the combustion chamber past the piston rings. This will result in a loss of power and an increase in oil consumption. Some oil consumption is mandatory if the piston rings are to be lubricated. With normal oil consumption, only a small amount of oil reaches the combustion chamber. However, the oil that does get to the combustion chamber must burn without leaving excessive deposits. Such deposits would have the effect of raising the compression ratio still higher. As an illustration of how combustion pressure increases with compression ratio, a typical 5 to 1 compression ratio cylinder having a combustion pressure of about 450 pounds per square inch would have a combustion pressure of over 800 pounds per square inch if the compression ratio were increased to 8 to 1. Increased temperature in the combustion chamber raises the piston temperature. Consequently, the oil which comes in contact with the piston must carry away more heat. As a result, the oil temperature is increased. Combustion temperatures in a modern automotive engine may reach a maximum of over 4000°F. whereas only a few years ago the maximum temperature was of the order of 2700°F. The effect of temperature on the crankcase oil will be discussed in detail later on.

The high compression ratio modern engine is more sensitive to the effects of combustion chamber deposits. The higher pressures and temperatures of the fuel-air mixtures increase the tendency for detonation and surface ignition to occur. The mechanisms of detonation and surface ignition are complex, but result in ignition of the air-fuel charge. For efficient combustion it is imperative that the start of combustion be precisely timed with the position of the piston in the cylinder. Uncontrolled combustion, or combustion which originates from any source other than the spark plug, will almost invariably result in loss of power, objectionable "combustion noise" and, if the condition is severe or prolonged, damage to the piston or valves. It has been found that the type and amount of combustion chamber deposits may have a pronounced affect on the tendency for detonation or surface ignition to occur in a high compression engine. Lubricant base oil type and additive type are definite factors in this respect.

Brake horsepower, the horsepower available for useful work, has also shown an appreciable increase, particularly during the last five years as shown in Figure 2. High horsepower by itself imposes no extra demands on the motor oil if the increase in horsepower is obtained by building a larger engine. The physical size of the engine, however, has increased only slightly, and considerable improvement has been made in the amount of power available from the unit volume of engine displacement. This is shown in Figure 3 which shows the brake horsepower per cubic inch of engine displacement. The average displacement of the automotive engines in 1946 was approximately 240 cubic inches, while in 1955 the displacement averaged about 276 cubic inches, an increase of only 15 per cent. During this same period, however, average maximum brake horsepower increased more than 65 per cent. The increased power output per unit displacement means a more efficient engine but also results in higher loads and temperatures.

Figure 4 shows the trend in engine speed, in revolutions per minute. The engine speed shown is the speed at which the engine develops its maximum brake horsepower. Although the increase in engine RPM does not appear to be large, it must be remembered that the inertia forces are proportional to the square of engine speed. Therefore, an increase in engine speed results in an appreciable increase in the loads and stresses imposed by the inertia forces. The higher speeds in the modern engine have been offset to some extent by the use of a shorter stroke and improvements in metallurgy and design which permit the use of lighter weight pistons.

The trend towards overhead valve V-8 engines in conjunction with the higher outputs per cubic inch has resulted in refinements in the mechanical design of individual engine components. The compactness and efficiency of the overhead valve design have brought about higher loads in the valve train mechanism. The lift and size of the valves have been increased to afford better breathing. This, coupled with the trend toward overhead valve design, has imposed additional loads on the valve train. Although metallurgical developments have resulted in metals which are more resistant to wear, the lubricant plays a vital role in minimizing wear of the cam lobes, valve lifters, and rocker arm shafts. One valve train component in particular, the hydraulic valve lifter, has presented additional demands upon the motor oil. Clearances between moving parts in an automotive engine cover a sizeable range but the hydraulic valve lifter has the smallest and most critical clearance. The purpose of this device is to provide quieter and more consistently efficient engine operation by maintaining zero valve lash. Because of the very small clearances within hydraulic valve lifters, they must be kept free of varnish and sludge deposits and must be protected against rust or corrosion. Small amounts of deposits can cause sticking; an increase in clearance due to corrosion or wear may allow the oil to escape too rapidly. In either case, objectionable noise results, valve opening and closing are interfered with, and the engine operates inefficiently.

The increased efficiency of the modern engine is dependent to a large extent on the ability of the

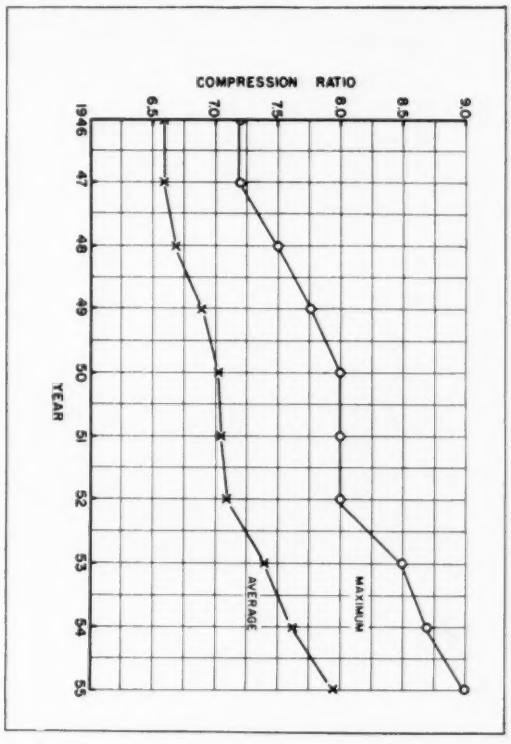


Figure 1 — Trend of passenger car compression ratio.

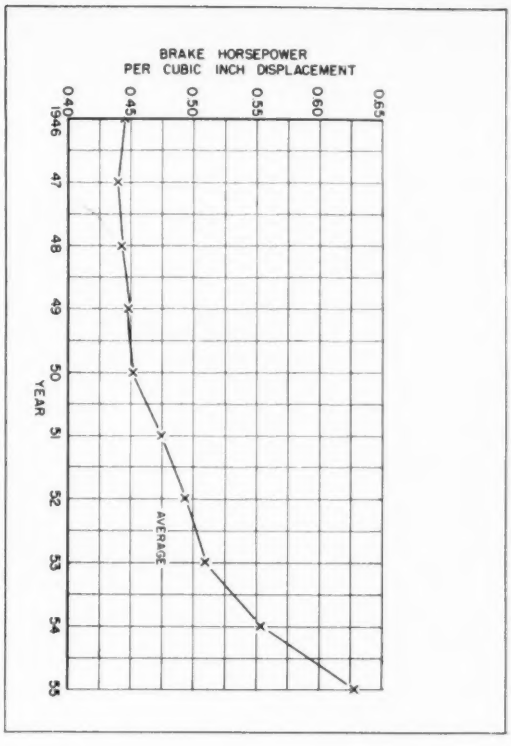


Figure 3 — Trend in b.h.p. per cu. in. of passenger cars.

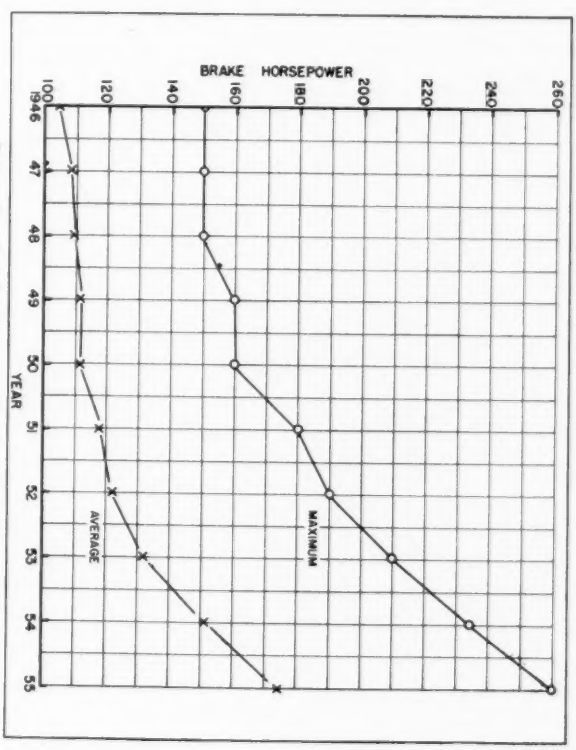


Figure 2 — Trend of passenger car brake horsepower.

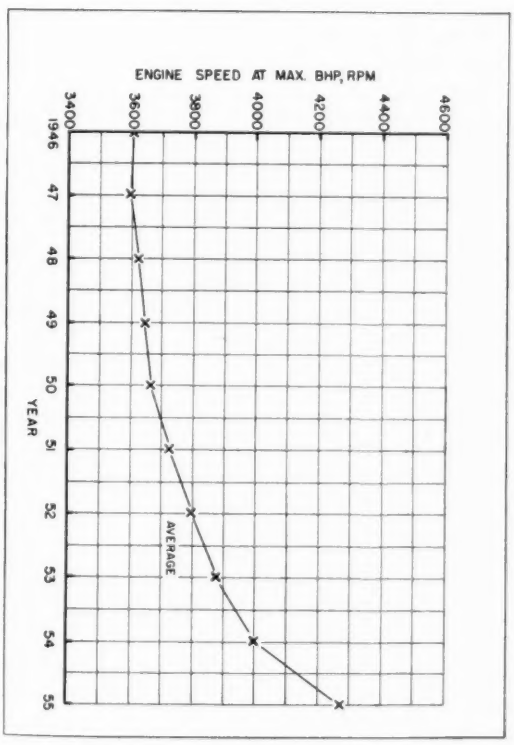
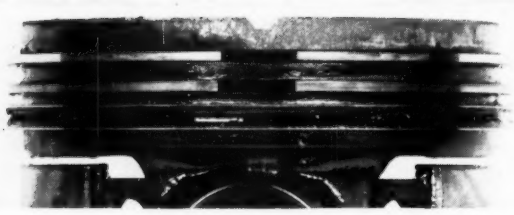


Figure 4 — Trend in rated engine speed.

Plugged oil ring.



Oil ring free of sludge.

Figure 5 — Low Temperature Operation.

engine to breathe freely. If the action of the valves is impaired by deposits on valve stems or wear of the valve train parts, engine breathing efficiency is reduced. Accordingly, the modern motor oil is expected to keep valve stems free of deposits to prevent valve sticking.

MODERN OILS

With this review of the changes in design of the automotive engine, it is now in order to take a look at the motor oils with which these modern engines are lubricated. Until about twenty years ago, practically all automotive engines were lubricated with straight mineral oils. Improvements in oil quality were then obtained solely by the development of new and better refining techniques. The oil industry, of course, is continually improving oil quality by new refining methods and judicious selection of crude oils. However, additives are now extensively employed to give the highly refined straight mineral oils characteristics which cannot be obtained by refining techniques alone. Although not a new development, a tremendous increase in motor oil quality has occurred during the last ten years through the use of additives. The fact that this improvement in motor oil quality coincided with the rapid changes in engine design was not a matter of chance but was a result of cooperation between the automotive and oil industries.

The functions of a crankcase oil are to:

1. Prevent wear.
2. Reduce friction.
3. Act as a cooling medium.
4. Act as a sealing agent.
5. Retard the formation of deposits on engine parts.
6. Act as a hydraulic oil in the hydraulic valve lifters.
7. Prevent rust and corrosion.

Straight mineral oils can perform these functions *provided* the engine operating conditions are not too severe. However, under moderate or severe conditions the use of additives can improve the performance of the oil immeasurably.

Today's quality motor oils may contain one or a combination of different types of additives. The types of additives which may be used are described briefly as follows:

1. Oxidation and/or corrosion inhibitors—Since oil will combine with the oxygen in the air to form materials which may be corrosive to certain engine parts or may lead to the formation of engine deposits, these additives are incorporated to retard this process.
2. Detergent dispersant — The purpose of these additives is to keep deposits or deposit forming materials dispersed throughout the oil and in an oil soluble condition so that they may be removed from the engine when the oil is drained.
3. Rust preventives — These additives, as the name implies, prevent rusting of the iron and steel parts of the engine.
4. Anti-wear agents — To retard wear of moving parts such as piston rings and valve train components.
5. Foam inhibitors — When oil and air are mixed vigorously, such as in an engine, a frothy mixture, foam, may form. Since foam, which is mostly air bubbles, cannot be pumped readily and is a very poor lubricant, additives may be added to minimize its formation or cause the foam to collapse rapidly.
6. Pour point depressants — Pour point, along with viscosity, is an indication of the ability of the oil to flow at low temperatures. Additives are available which reduce the normal pour point of the oil and permit it to flow at lower temperatures.

Viscosity Index Improver additives may also be used. Viscosity Index will be discussed later on along with viscosity since the two are so closely related.

DEPOSITS AND WEAR

As pointed out earlier, modern engines are small and compact but more powerful and efficient than their predecessors. The car owner expects, and rightly so, that the power built into this modern

engine be instantly available at all times and that the efficiency be maintained for many thousands of miles. Because these engines are more powerful and more efficient but with smaller clearances, the harmful effects of deposits and wear are more pronounced. The conditions under which an automotive engine is operated have a considerable influence on the duties which the motor oil must perform. Some types of operation are more severe than others, but the motor oil must take care of the severe as well as the mild.

Low Temperature Operation

One type of operation which is severe, as well as being quite common, is at low engine temperatures. Examples of this condition are starting and warm-up, intermittent stop-and-go driving, and short trip driving. An engine is considered to be operating at a low temperature, or as a "cold" engine, when the crankcase-oil temperature is below 140°F. even though the cooling water temperature is above 140°F. If both the cooling water and oil temperatures are below 140°F., the operation is even more severe. This condition is usually encountered during the winter months, but can occur even during warm weather if the engine is used only for very short trips and does not have a chance to warm up.

There are several factors which combine to make low temperature operation difficult to combat. During the combustion of the air-fuel mixture, water vapor is formed. At normal temperatures this vapor is no problem since there are no cold surfaces on which the vapor will condense. With a cold engine, the water vapor condenses on the relatively cold cylinder walls and is carried into the crankcase by the action of the oil rings. Since the oil pan is also cold, any water vapor which reaches the crankcase, as a result of blow-by past the piston rings, will also condense. Blow-by with a cold engine is greater than with a warm engine because the piston and ring clearances are somewhat greater.

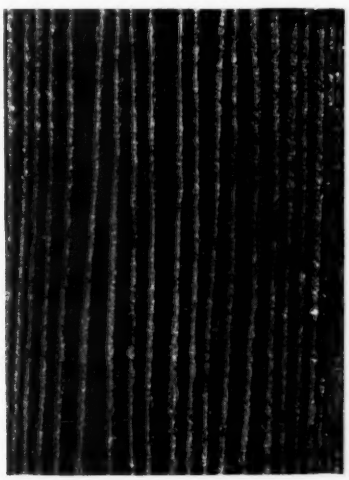
The water in the oil mixes with other oil contaminants to form a soft grey paste known as low temperature sludge. If the oil does not keep this material dispersed, it will deposit on the parts of the engine. Oil rings may become plugged with sludge and will not be able to perform their function of controlling cylinder wall lubrication. The upper portion of Figure 5 shows the nearly plugged oil ring from an engine which used a straight mineral oil; the lower portion shows the oil ring from an engine which used a high quality motor oil. This is nearly free of deposits.

Deposits of this kind can also plug an oil filter quite rapidly. The filter then cannot remove abrasive material, such as dust, and engine wear will increase. Figure 6 shows two paper type filters with the outer cover removed. The filter on the left is completely plugged and is ineffective. The filter on the right is relatively free of sludge and is still capable of filtering out contaminants.

Low temperature sludge may accumulate on the oil screen and if allowed to build up will reduce the flow of oil to the engine oil pump. If carried to extremes, the oil screen may become completely plugged, stopping the flow of oil to the engine, and engine failure will result. The same thing can happen if this sludge accumulates in oil passages to such an extent that the passage becomes plugged.

Water in the engine has other harmful effects in addition to the formation of low temperature

Filter plugged with sludge.



Sludge-free filter.

Figure 6 — Oil Filters

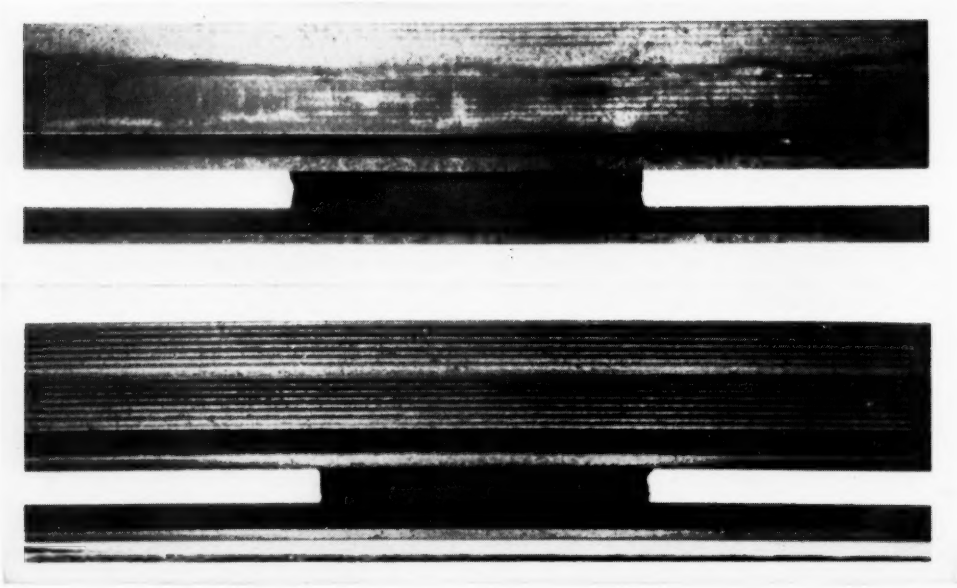


Figure 7 — Low temperature operation. Worn and corroded piston rings (top) as contrasted with piston rings in good condition (bottom).

sludge. When the engine is operating cold, the fuel-air mixture is not burned as completely as in a warm engine. Some of these products of incomplete combustion combine with the water to form acidic materials which are corrosive. Cylinder walls, piston rings or the inner surfaces of the hydraulic valve lifters may become pitted by corrosive action. These pits in themselves are a form of "wear", but the pits also promote more wear by making the surface rough and more difficult to lubricate. The upper portion of Figure 7 illustrates the low temperature wear obtained with a straight mineral oil. The rings in the lower portion of Figure 7 were run with a high quality additive motor oil. It may be noted that most of the tool marks are still visible on the rings run with the high quality oil while the rings run with the straight mineral oil are worn and pitted.

The presence of water also promotes rusting of the iron or steel parts of the engine. If water is present, rusting can occur with the car sitting in the garage. Rust is a form of corrosion or wear but the rust particles, when scraped off the engine parts into the oil, will act as an abrasive and accelerate wear. Parts which are subject to corrosive attack include piston rings, valve stems or guides, hydraulic lifters, crankshaft, camshaft, and rocker arms.

Other contaminants which enter the oil when operating the engine cold are oxidized materials from the heavy ends of the unburned fuel and fuel soot, small carbon particles like lampblack. Both of these contaminants add to the formation of low temperature sludge. The fuel oxidation products may also result in the formation of a varnish-like deposit on engine parts. The internal parts of a hydraulic valve lifter are represented by the small plungers shown in Figure 8. These plungers illustrate what may happen during low temperature operation. The one on the left showed satisfactory performance with only a small amount of stain at the bottom. Next to this is a plunger showing considerable varnish deposits which were more than enough to cause this plunger to stick. The third shows both varnish deposits and corrosion. The fourth shows considerable pitting as a result of rusting and corrosion.

In addition to all of the undesirable effects of cold engine operation already discussed, the oil also becomes diluted with gasoline. This happens because the cold engine runs with an excessively rich fuel-air mixture and all of the fuel does not vaporize. This liquid gasoline is then scraped off the cylinder walls by the oil rings and carried into the crankcase. This has two harmful effects; (1) the gasoline has a washing action which removes some of the oil from the cylinder walls making piston ring and cylinder wall lubrication even less effective, and (2) the gasoline dilutes the oil and reduces its viscosity. If cold engine operation is continued too long, dilution of the oil with gasoline may reduce the viscosity of the oil to such an extent that it can no longer provide a sufficiently thick film between moving parts. This promotes rapid engine wear and eventual engine failure.

The problem of low temperature sludge has not been completely solved, although considerable progress has been made in recent years in develop-

ing oils which combat this type of sludge. Good maintenance and regular oil drains aid appreciably in keeping this type of sludge from accumulating in the engine.

High Temperature

At the opposite end of the severity scale is engine operation at high temperature; specifically, high crankcase oil temperature. This condition is encountered while driving at high speeds during warm weather. As engine speed and load are increased, the amount of heat rejected to the crankcase oil increases and the oil temperature rises. The crankcase oil, when exposed to high temperature for a sufficiently long period of time, will oxidize; that is, the oil combines chemically with the oxygen in the air. The rate at which oil oxidizes depends to a great extent upon temperature – the higher the temperature, the greater the tendency to oxidize. Many parts of a modern automotive engine operate at high temperatures. For example, the piston rings may run as high as 600°F., the piston skirt and connecting rod bearings up to 400°F., and the main bearings up to 350°F. All of these high temperature parts of the engine contribute to increasing the bulk oil temperature and, hence, to oil oxidation. Unfortunately, if an oil is not made resistant to oxidation, oil oxidation will progress like a snowball rolling downhill. That is, the higher the rate of oxidation, the more oxidized material will be present and the greater the amount of oxidized material present, the higher the rate will be. If air, the source of oxygen, could be excluded, the oil would not oxidize. It is not possible to seal the crankcase to prevent contact with air. From the discussion of low temperature operation, it is apparent that it is necessary to ventilate the crankcase to remove as much of the blow-by gases, water vapor and fuel vapors as possible. In addition, if the crankcase were not ventilated, the blow-by gases would build up pressure in the crankcase and force oil out of the crankcase, creating excessively high "oil consumption". Since it is not possible to exclude oxygen or the high temperatures, the obvious solution is to make the oil more resistant to oxidation.

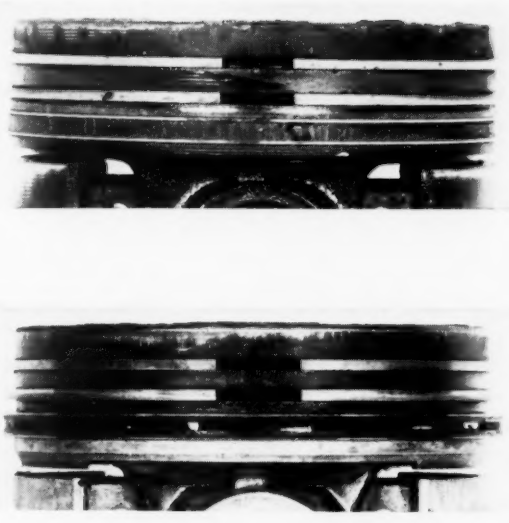


Figure 9 – Piston ring belt deposits. Note the completely plugged oil ring in upper photo.

Materials which are formed by the oil oxidizing will cause engine deposits. An example of what can happen if an oil which was not adequately fortified to combat oxidation is operated at high oil temperatures for long periods is shown by the plugged oil ring in the upper portion of Figure 9. These high temperature deposits have the same effect on the function of the oil ring as the low temperature deposits, even though the reason for the deposit and type of deposit are different. It is

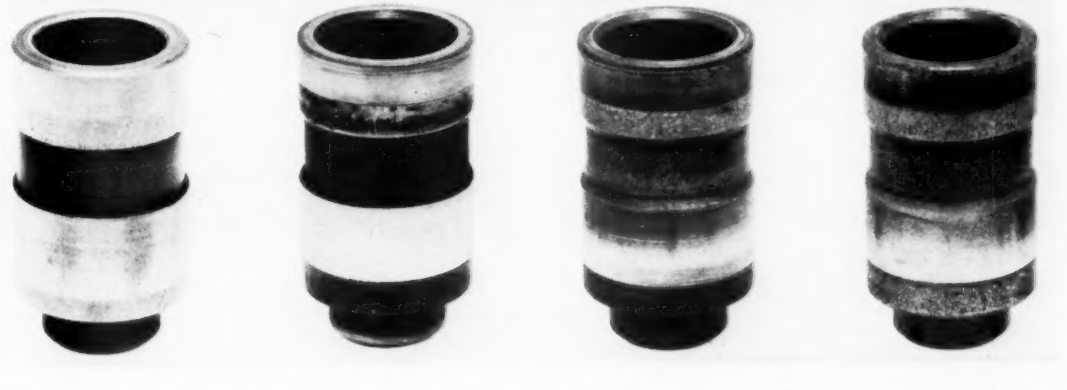


Figure 8 – Low temperature operation. Typical hydraulic valve lifter deposits and corrosion. The plunger on the left is in good condition and is shown for comparison.

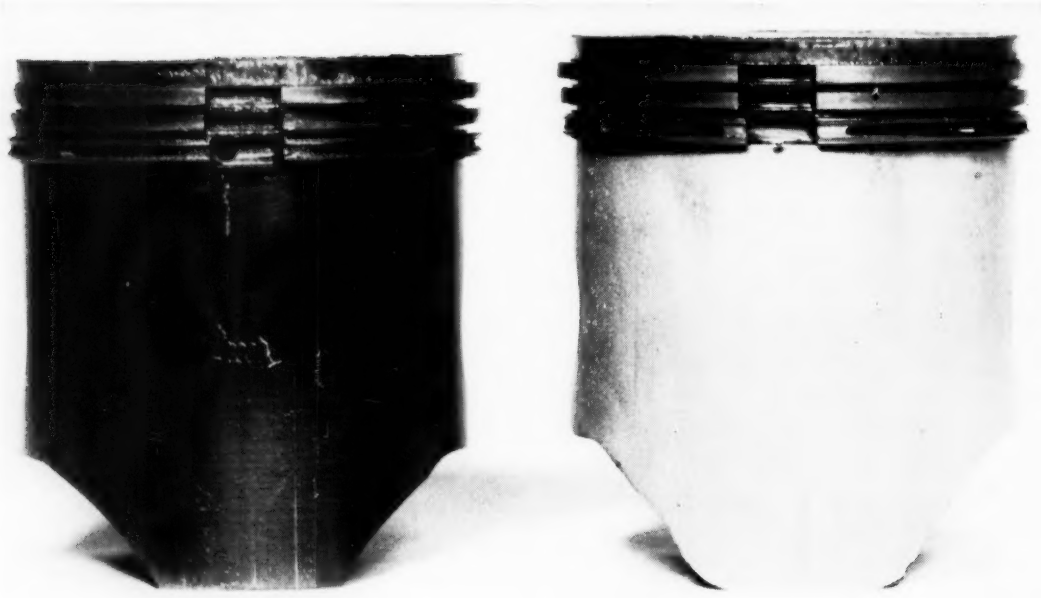


Figure 10 — Piston skirt deposits formed by oils of different quality level.

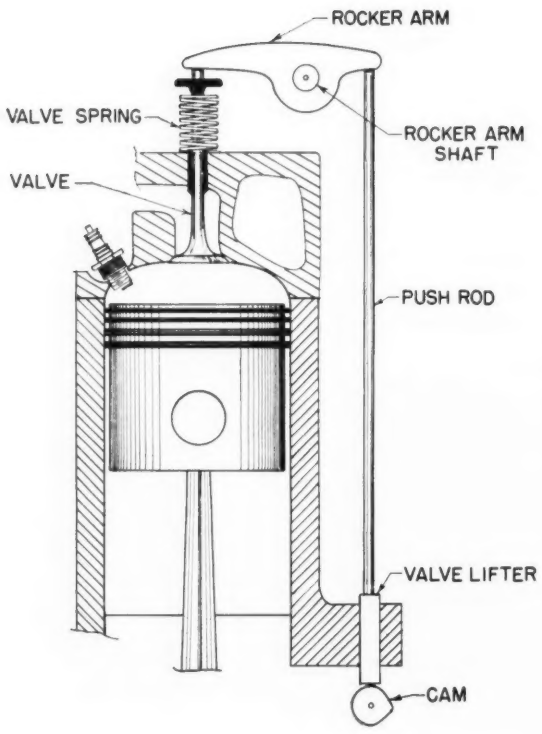


Figure 11 — Valve train components.

quite obvious that this engine would have to be overhauled to restore it to its proper operating efficiency. This ring is an extreme case since it is totally plugged but any deposits which interfere with the oil ring's function of controlling the lubrication of cylinder walls and rings will reduce the efficiency of the engine. The oil ring shown in the lower portion of Figure 9 indicates what is expected of a modern high quality motor oil.

High speed, high temperature operation also forms harmful deposits on other engine parts if an oil of insufficient quality is used. Two pistons taken from engines operated in this manner are shown in Figure 10. The piston on the left was operated on a straight mineral oil while the piston on the right was from an engine operated on one of today's premium motor oils. It is apparent that the straight mineral oil was unable to prevent the formation of deposits under severe operating conditions. Hydraulic valve lifters, with their small clearances, will also be rendered inoperative if the oil allows deposit formation. As pointed out earlier, the clearances in this ingenious little mechanism are very small, only one or two ten thousandths of an inch. With such small clearances only a very small amount of deposit will interfere with proper operation.

An illustration of lifter deposits is shown in Figure 8. High temperature deposits, although of a different nature, have the same undesirable result of causing the lifter to stick.

Wear of any of the valve train components may

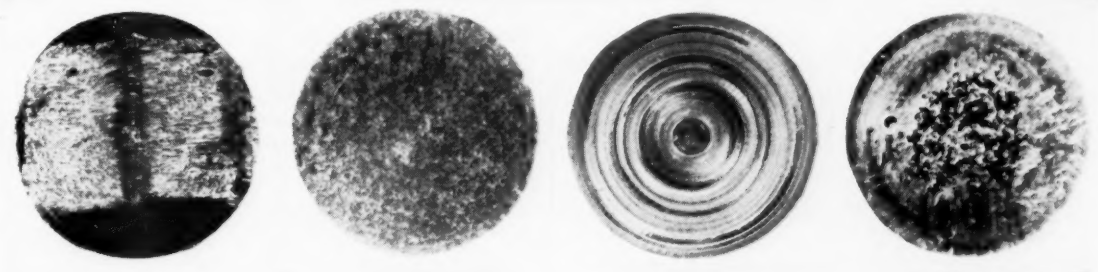
Worn cam. Good cam.

Figure 12 — Camshaft lobe wear.

be quickly reflected in a reduction in engine performance. Referring to Figure 11, critical points with respect to wear in the valve train are the cam lobe, the base of the lifter and the rocker arm shaft. Wear in any of these locations will result in a decrease in valve lift and a consequent reduction in the efficiency of both the intake and exhaust strokes. To combat wear in these parts, certain anti-wear agents are added to the oil. Figure 12 shows a cam which shows wear of the nose and also a cam which has undergone little wear. Figure 13 shows several lifter faces, that part of the lifter which rides on the cam. These lifters were obtained in laboratory tests and illustrate various types of wear.

The type of wear experienced is dependent upon the metallurgical combinations involved, the valve train geometry, the operating conditions as well as the lubricant. The lifter shown in Figure 14 is unusual as the lifter face has been worn almost to a concave hemisphere. Once the face of the lifter has spalled or scuffed badly, it is usually not long before the cam starts to wear. It is possible, however, for the cam to wear without corresponding damage to the lifter. Figure 15 shows both a worn and a good rocker arm shaft.

The type and amount of deposits formed in the combustion chamber is a function of the type of fuel and lubricant used, together with the type of engine operation. Combustion chamber deposits may lead to detonation, surface ignition, spark plug malfunctioning, and burned or leaky valves. The octane number of the lowest octane numbered reference fuel which will allow an engine to operate knock free is termed the octane requirement of the engine. If the octane requirement of an engine is obtained with a clean combustion chamber, it will be found that as deposits accumulate the octane requirement will increase. This increase will generally continue until deposit formation has reached equilibrium. (Equilibrium occurs when deposits flake off the walls of the combustion chamber at about the same rate as new deposits are formed.) The octane requirement at equi-



Non-Rotating Scuffed Lifter. Good Lifter. Rotating Scuffed Lifter. Pitted Lifter.

Figure 13 — Typical valve lifter face wear.

Figure 14 — Drastic wear of valve lifter face.

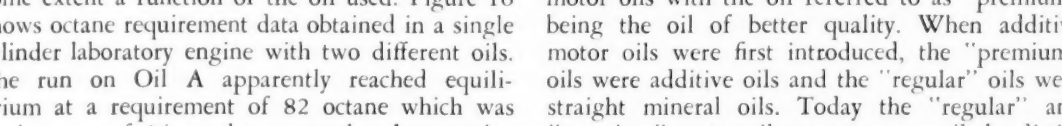
librium together with the fuel used determine whether or not the engine will operate "knock-free". The equilibrium octane requirement is to some extent a function of the oil used. Figure 16 shows octane requirement data obtained in a single cylinder laboratory engine with two different oils. The run on Oil A apparently reached equilibrium at a requirement of 82 octane which was an increase of 24 numbers over the clean engine requirement. An increase of 12 numbers was noted for the run on Oil B. Although differences between oils are greatly magnified by this laboratory test procedure, the data do serve to illustrate that oils are different with respect to combustion chamber deposit forming characteristics.

The use of an inferior oil is only one of the many reasons for valve troubles. Since the valves must seal the combustion chamber on every power stroke, anything which interferes with the valve operation reduces the power output of the engine. If the valves do not close completely, the hot combustion gases will burn the face of the valve and necessitate an overhaul to restore the engine to its normal operating efficiency. No attempt is made to lubricate the valve face since the sealing action is obtained here by metal-to-metal contact. The oil does, however, lubricate the valve stem and valve guide.

Deposits on valve stems can accumulate until there is no clearance between the valve stem and the valve guide. If the valve spring cannot overcome the increased friction caused by the deposits, the valve stem will stick in the guide and the valve will be held open. The oil is expected to lubricate the valve stem and at the same time keep stem deposits to a minimum. Shown at the right in Figure 17 is an intake valve stem with heavy deposits which lead to valve sticking; on the left in Figure 17 is a clean valve stem for comparison. Rusting of valve stems or iron valve guides can have the same effect as deposits. Rust can also result in valve sticking. Rust can form during low temperature operation or when the engine is inoperative for fairly long periods. To insure protection against troublesome rust formation in this location, the oil must be suitably rust inhibited.

OIL CLASSIFICATION

In general, there are usually motor oils of two different quality levels available to the car owner at service stations. It has become common practice to refer to these two oils as "regular" and "premium" motor oils with the oil referred to as "premium" being the oil of better quality. When additive motor oils were first introduced, the "premium" oils were additive oils and the "regular" oils were straight mineral oils. Today the "regular" and "premium" motor oils cannot necessarily be distinguished by saying that one is a straight mineral oil while the other is an additive oil, since many "regular" motor oils today may contain a corrosion and/or oxidation inhibitor, V.I. improvers or pour depressants. The premium oils normally contain oxidation and corrosion inhibitors, detergent-dispersant type additives and usually others of the additive types previously described. The military have set up specifications, including engine tests, which an oil for heavy duty service must meet. Motor oils meeting the heavy duty requirements are available, and reliable marketers generally clas-



Good shaft. Worn shaft.

Figure 15 — Rocker arm shaft wear.

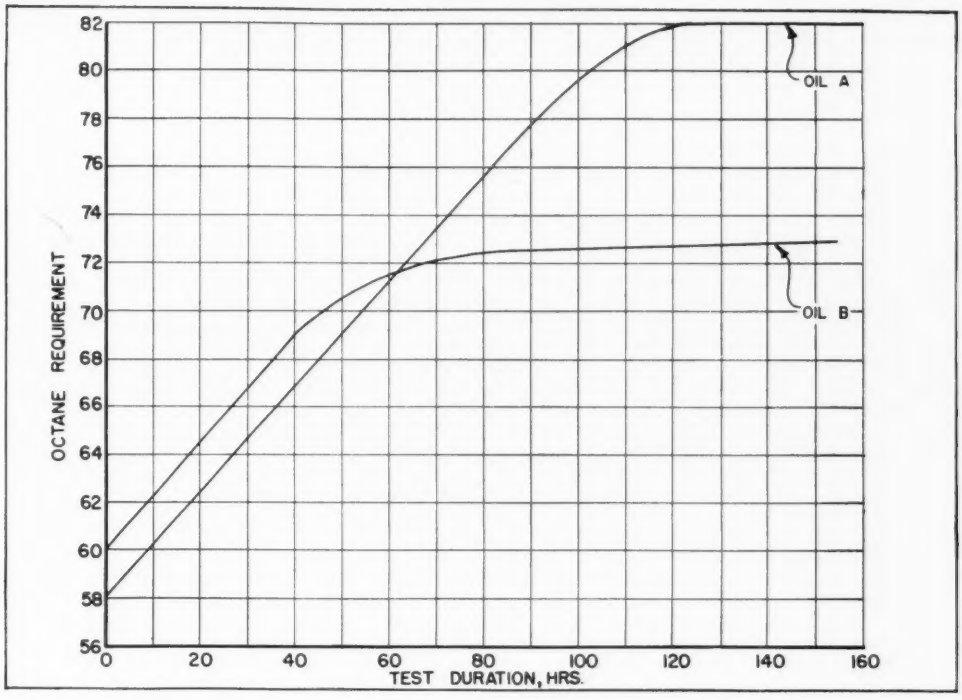


Figure 16 — Octane requirement vs. time. Single cylinder laboratory engine.

sify their motor oils as heavy duty oils only when they qualify at this performance level.

The SAE viscosity numbers shown in Table I are a classification for motor oils in terms of viscosity only. Oil quality is not considered in the viscosity classification. Viscosity numbers without an additional symbol are based on the viscosity at 210° F. Viscosity numbers followed by the letter "W" are based on the viscosity at 0° F.

Viscosity is a measure of the fluid friction and therefore is related to the rate at which an oil flows. The greater the viscosity, the less fluid the oil. One of the most common measurements of viscosity is the Saybolt Universal wherein the viscosity is expressed as the number of seconds of time required for a given amount of oil to flow through a standard size hole or orifice. Viscosity is usually determined at temperatures of 100, 130 and 210° F. Viscosities at other temperatures may then be obtained by use of a viscosity-temperature chart. Viscosity will vary inversely with temperature; that is, the colder an oil, the more sluggish or viscous it becomes. As the temperature is raised, the same oil will become more and more fluid.

The various car manufacturers in their "owner's manual" recommend SAE viscosity number oils that vary with the season of year; that is, lower viscosity for low temperature winter operation. These recommendations are based on the fact that the lower viscosity oils have less resistance to flow

Figure 17 — Intake valve stem deposits.

TABLE I
Oil Classification by SAE Viscosity Numbers

SAE Viscosity Number	*Viscosity Range, Saybolt Universal Seconds*			
	at 0°F.		*at 210°F.*	
	Min.	*Max.*	*Min.*	*Max.*
5W	—	4,000	—	—
10W	6,000 (Note A)	Less than 12,000	—	—
20W	12,000 (Note B)	48,000	—	—
20	—	—	45	Less than 58
30	—	—	58	Less than 70
40	—	—	70	Less than 85
50	—	—	85	Less than 110

Note A: Minimum viscosity at 0°F. can be waived provided viscosity at 210°F. is not below 40 Saybolt Seconds Universal.
Note B: Minimum viscosity at 0°F. can be waived provided viscosity at 210°F. is not below 45 Saybolt Seconds Universal.

and therefore provide easier cold weather starting. Higher viscosity oils are used in hot weather to insure that a good film of oil is maintained between moving parts at the higher operating temperatures.

By inspection of Table I, it may be noted that oils could meet the requirements of more than one SAE viscosity number if their viscosities at 0°F. and 210°F. were in the proper range. For example, an oil with a viscosity of less than 12,000 seconds at 0°F. and a viscosity of 58 to 70 seconds at 210°F. would meet the requirements of both an SAE-10W and an SAE-30. In the same manner it is possible to make oils meeting both SAE-5W and SAE-20 or SAE-10W and SAE-20.

Multi-viscosity number oils are now being manufactured and marketed. Such oils, of course, have the advantage of possessing low viscosity for ease of starting and have sufficient viscosity to provide satisfactory lubrication at higher temperatures.

Viscosity Index is a calculated value based on known viscosities at 100 and 210°F. and indicates the rate at which the viscosity of an oil changes as the temperature of the oil is increased or decreased. For two oils having the same viscosity at 210°F. but of different V.I., the oil having the higher V.I. will have a lower viscosity at 100°F. or at 0°F. than the oil with the lower V.I. Small differences in V.I. are quite meaningless when the viscosity at normal operating temperatures in engines is considered. High V.I. should never be regarded as a complete yardstick of motor oil quality since many other factors must be considered in compounding a motor oil of high quality.

OIL DRAINS

Why change the crankcase oil? The statement is frequently heard that oil does not wear out. It is not because the oil wears out that oil changes are required. Rather, it is the accumulation of contaminants in the oil as well as changes in the oil itself that make oil changes necessary. The previous sections have shown how engine deposits and wear are kept at a low level by the use of high quality motor oils. It should be remembered, however, that the engine is continually forming materials that can be deposit forming or be conducive to wear if the oil does not prevent them from doing so. If the oil is used for too long a time, even the highest quality oil will be overburdened and cannot be expected to function properly. During the winter with the low temperature operation encountered, the oil becomes contaminated with water and diluted with gasoline which must be removed. In addition, dust in the air enters the crankcase, either through the crankcase ventilator or by way of the cylinders and past the piston rings. Carburetor air filters, crankcase ventilator filters and oil filters remove part of the dust but they seldom provide full protection and periodic oil drains are the only sure way of removing these abrasive dust particles which promote wear.

SUMMARY

It has been shown that automotive engine design changes have been made which place new demands on the motor oils. The development of higher quality motor oils to meet these new requirements has occurred concurrently with the development of the new engines. The outstanding performance characteristics of modern motor oils is the result of extensive research and close cooperation between the automotive and petroleum industries. Today's modern motor oils, in conjunction with good maintenance, aid appreciably in attaining efficient, economical and long engine life.

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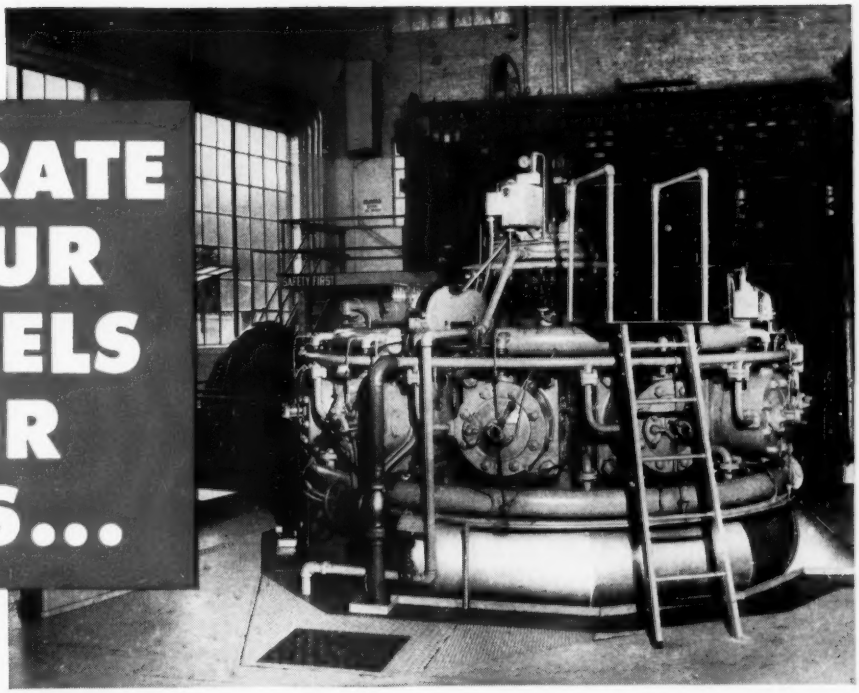

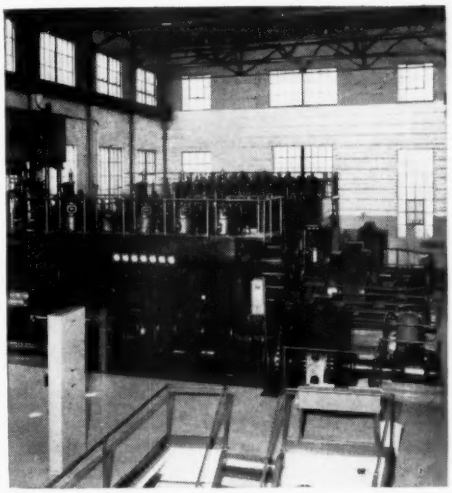

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